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METHOD FOR FABRICATING LIQUID CRYSTAL DISPLAY DEVICE AND SEALING MATERIAL THEREFOR

[Abstract]

PROBLEM TO BE SOLVED: To solve the problem of a desired cell gap unable to be stably obtained, because of difficulty in management of height and extents of deformation of color layers, in the case that color filter substrate where film thickness is different by color layers is used in a liquid crystal panel, in a beadless system where projections are used to hold the cell gap.

SOLUTION: In a method for manufacturing the liquid crystal panel, the height and extent of deformation of projections are managed by the height and extent of

deformation of projections placed on the thickest color layer out of color filter color layers, on which projections are placed not only in the case projections are provided on the color filter substrate but also in the case projections are provided on a counter substrate.

[Claim(s)]

[Claim 1]

A method for manufacturing a liquid crystal panel, the method comprising the steps of:

forming a protrusion for allowing for overlapping color filter layers of at least two colors on a color filter substrate including a plurality of color filter layers having different thicknesses;

bonding the color filter substrate and a substrate opposite to the color filter substrate with the protrusion interposed therebetween; and

injecting a liquid crystal between the color filter substrate and the opposite substrate,

wherein the height of the protrusion is controlled by the height of a protrusion that overlaps a color filter layer having the largest thickness among the color filter layers of at least two colors having different thicknesses.

[Claim 2]

A method for manufacturing a liquid crystal panel, the method comprising the steps of:

forming a protrusion for allowing for overlapping color filter layers of at least two colors on a color filter substrate including a plurality of color filter layers having different thicknesses;

bonding the color filter substrate and a substrate opposite to the color filter substrate with the protrusion interposed therebetween; and

injecting a liquid crystal between the color filter substrate and the opposite substrate, wherein a deformation in the height of the protrusion is controlled by the deformation in the height of a protrusion that overlaps a color filter layer having the largest thickness among the color filter layers of at least two colors having different thicknesses.

[Claim 3]

A method for manufacturing a liquid crystal panel, the method comprising the steps of:

forming a protrusion for allowing overlapping color filter layers of at least two colors on a substrate disposed opposite to a color filter substrate including a plurality of color filter layers having different thicknesses after panel assembling;

bonding the color filter substrate and the opposite substrate with the protrusion disposed therebetween; and

injecting a liquid crystal between the color filter substrate and the opposite substrate, wherein deformation in the height of the protrusion is controlled by deformation in the height of a protrusion that overlaps a color filter layer having the largest thickness among the color filter layers of at least two colors having different thicknesses.

[Title of the Invention]

METHOD FOR FABRICATING LIQUID CRYSTAL DISPLAY DEVICE AND SEALING MATERIAL THEREFOR

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to a method for manufacturing a liquid crystal panel using a protrusion to support a cell gap.

[Description of the Prior Art]

The prior art will be described with reference to FIG. 7.

A liquid crystal panel is composed by bonding two substrates, i.e., a color filter substrate 11 and a substrate 12 that is disposed opposite to the color filter substrate 11. However, to maintain a gap between the color filter substrate 11 and the opposite substrate 12 constant, a spacer should be installed.

Conventionally, as a spacer, divinylbenzene-group or Benzoguanamine-group resin spherical beads 51 or Zirconium oxide-group inorganic spherical beads 51 are distributed over one of the two substrates 11 and 12. Thereafter, the two substrates 11 and 12 are bonded.

Such a bead distribution method is employed in assembling of most of currently produced liquid crystal panels for its simplicity.

However, with the recent demand for improvement in display quality of a liquid crystal panel, the following should be addressed. In other words, (1) leakage of light from the distributed beads 51 and from a neighboring area of the distributed beads 51 and display non-uniformity or contrast degradation due to leakage of light caused by cohesion of the beads 51 during distribution, (2) improvement in cell gap uniformity, (3) degradation of cell gap uniformity due to movements of the beads 51 when vibration is applied to a liquid crystal panel or a scratch on the surface of an alignment layer 4, and (4) cell gap non-uniformity due to deposition of the beads 51 on a filter layer 3 when a load is concentrated on a portion of the liquid crystal panel should be addressed.

To solve such problems, a structure having no beads to be distributed is being considered and has been already used in some products. In the structure, resin protrusions are formed on the color filter substrate 11 or the opposite substrate 12 using lithography or the like to have a uniform height at predetermined intervals and are used as a spacer for maintaining a cell gap constant.

[Problem(s) to be Solved by the Invention]

However, the resin protrusions formed on the color filter substrate or the opposite substrate have large plastic deformation and their height are lowered due to a process that imposes a heavy load on a substrate having protrusions, such as an alignment layer printing process, a seal printing process, a seal hardening process, a vacuum injecting process, and a sealing process, during assembling of a liquid crystal panel.

In the case of a structure having no bead, a cell gap is determined by the height of protrusions formed on a substrate and deformation in the height of the protrusion during assembling of a liquid crystal panel. In such a structure, it is important to properly control the height and deformation in the height of the protrusions for stability of a cell gap.

In general, it is easy to control the height or deformation in the height of protrusions by forming the protrusions whose color overlap with one of three colors of color filter layers, i.e., red, blue, and green. However, in terms of intensive designing (the number of protrusions per unit area), at least two colors of the color filter layers may overlap with the protrusions.

Recently, for high color purity of a color filter substrate and a liquid crystal panel, the thicknesses of the color filter layers (red, green, and blue) are designed to be different from one another.

It is general that a pattern is formed through exposure or development after a register that is a material for protrusions is coated onto a substrate by a spin coater. However, when a protrusion is formed on a color filter substrate in which color layers have different thicknesses, the height or deformation in the height of the protrusions change according to the color layers. Since the steps between color layers (generally, red, green, and blue) are leveled during register coating, as shown in FIG. 5, a sum of a layer thickness and the height of a protrusion is the same over the color layers, but a leveling effect is not necessarily flawless.

When protrusions are formed on a substrate disposed opposite to a color filter substrate, the height of protrusions are uniform but deformation in the height of the protrusions changes with the thickness of each color layer of the color filter substrate, which overlaps the protrusions.

In this way, when using a color filter substrate having color layers of different thicknesses, it is difficult to control the height and deformation in the height of protrusions and to stably obtain a desired cell gap even though the protrusions are formed on one of a color filter substrate and a substrate opposite to the color filter substrate.

[Means for Solving the Problem]

To solve the problems, the present invention provides a method for manufacturing a liquid crystal panel, in which the height and deformation in the height of protrusions are controlled based on the height and deformation in the height of a protrusion that overlaps a color filter layer having the largest thickness among color filter layers that overlap the protrusion, even when the protrusions are formed on a color filter substrate or a substrate opposite to the color filter substrate.

[Embodiment of the Invention]

According to one aspect of the present invention, there is provided a method for manufacturing a liquid crystal panel. The method comprises the steps of forming a protrusion for allowing for overlapping color filter layers of at least two colors on a color filter substrate including a plurality of color filter layers having different thicknesses, bonding the color filter substrate and a substrate opposite to the color filter substrate with the protrusion disposed therebetween, and injecting a liquid crystal between the color filter substrate and the opposite substrate. The height of the protrusion is controlled by the height of a protrusion that overlaps a color filter layer having the largest thickness among the color filter layers of at least two colors having different thicknesses.

According to one aspect of the present invention, there is provided a method for manufacturing a liquid crystal panel. The method comprises the steps of forming a protrusion to overlap color filter layers of at least two colors on a color filter substrate including a plurality of color filter layers having different thicknesses, bonding the color filter substrate and a substrate opposite to the color filter substrate with the protrusion disposed therebetween, and

injecting a liquid crystal between the color filter substrate and the opposite substrate. Deformation in the height of the protrusion is controlled by deformation in the height of a protrusion that overlaps a color filter layer having the largest thickness among the color filter layers of at least two colors having different thicknesses.

According to one aspect of the present invention, there is provided a method for manufacturing a liquid crystal panel. The method comprises the steps of forming a protrusion for allowing overlapping color filter layers of at least two colors on a substrate disposed opposite to a color filter substrate including a plurality of color filter layers having different thicknesses after panel assembling, bonding the color filter substrate and the opposite substrate with the protrusion disposed therebetween, and injecting a liquid crystal between the color filter substrate and the opposite substrate. Deformation in the height of the protrusion is controlled by deformation in the height of a protrusion that overlaps a color filter layer having the largest thickness among the color filter layers of at least two colors having different thicknesses.

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompany drawings.

(First embodiment)

It is determined control of the height and deformation in the height of which color layer is most effective, through provision of 13.3 inch XGA color filter substrate and assembling of a 13.3 inch XGA TFT liquid crystal panel.

First, as shown in Table 1, four color filter substrates a1, a2, b1, and b2 having different thicknesses for different colors and four array substrates c1, c2, d1, and d2 that constitute a substrate 12 disposed opposite to a color filter substrate are provided.

[Table 1]

Substrate No.	Red layer thickness (μm)	Green layer thickness (μm)	Blue layer thickness (μm)
a1, a2 b1, b2	1.5	1.65	1.8

First, with respect to a case where a protrusion 52 is formed on a color filter substrate 11, panel assembling is performed and a liquid crystal panel in which R>1 as shown in FIG. 1 is made.

An acryl-group register material is applied on the color filter substrate a1 to a thickness of 3.7μm and on the color filter substrate b1 to a thickness of 4.7μm, and pre-baking, ultraviolet ray exposure using a predetermined mask, development, and post-baking are performed to form the protrusion 52. After the register material is applied on a component glass and post-baking is performed, the thickness of the register material is determined by being measured by a stylus type step system.

At this time, as shown in FIG. 2, the protrusion 52 is arranged at a density of 1 per 4 dots and is uniformly distributed over color layers 3R, 3G, and 3B of red, green, and blue. A result of measuring the height of the protrusion 52 in each color layer is shown in Table 2.

[Table 2]

A panel in which a protrusion is formed on a color filter substrate

Color filter substrate No. (opposite substrate No.)	Color layer corresponding to position in which protrusion is formed	After formation of protrusion, Protrusion height; Color layer thickness + Protrusion height (µm)	After disassembling, Color layer thickness; Protrusion thickness(µm)	Before and after assembling, Deformation in the height of protrusion height (µm)
a1 (c1)	Red	3.64 5.14	3.45 4.95	0.19
	Green	3.53 5.23	3.37 5.02	0.21
	Blue	3.53 6.33	3.28 5.08	0.25
b1 (d1)	Red	4.64 6.14	4.40 5.90	0.24
	Green	4.55 6.23	4.30 5.95	0.28
	Blue	4.50 6.30	4.19 5.99	0.31

Predetermined cleaning, alignment printing, and alignment layer hardening, and then rubbing in a predetermined direction and cleaning are performed on the two color filter substrates a1 and b1 and two opposite substrates c1 and d1 among the four opposite substrates 12. At this time, an alignment layer 7 uses a polyimide-group material and its thickness is 50 – 80nm.

Next, seal printing is performed on the color filter substrates 11 and conductive paint coating is performed on the opposite substrates 12. At this time, a glass fiber having a length of 5.2μm is contained in the seal material.

After the opposite substrates 12 is bonded to the two color filter substrates 11, seal hardening, glass division cutting, vacuum injection of a liquid crystal 8, and a predetermined process for inlet sealing are performed, thereby making two liquid crystal panels. The color filter substrates 11 and the opposite substrates 12 are bonded such that the color filter substrates a1 and b1 are bonded to the opposite substrates c1 and d1, respectively.

The two liquid crystal panels are disassembled and the height of the protrusion 52 on the color filter substrates 11 is measured in each color layer. A result of disassembling the two liquid crystal panels is shown in Table 2 with a result after formation of the protrusion 52.

The effect of leveling of steps of color filter layers due to the protrusion 52 is not more efficient than the result of Table 2 in any of a protrusion forming process and a panel assembling process. As shown in FIG. 3, a sum of the thickness of each of the color layers 3R, 3G, and 3B and the height of the protrusion 52 is not uniform. A sum of the thickness of each color layer and the height of a protrusion is the largest in a color layer having the largest thickness (the color layer 3B in this embodiment).

FIG. 5 is a schematic view when the leveling effect is sufficiently obtained.

From the above result, a protrusion formed in a color layer having the largest thickness supports a cell gap of a liquid crystal panel and it is efficient to control the height and deformation in the height of a protrusion formed on a color layer having the largest thickness for stability of a cell gap.

(Second embodiment)

Next, a description will be made regarding a case where the protrusion 52 is formed on the opposite substrate 12. After panel assembling, a liquid crystal panel shown in FIG. 8 is made.

An acryl-group register material is applied on the remaining substrates c2 and d2 among the four opposite substrates 12. The acryl-group register material is applied to a thickness of 3.7μm on the substrate c2 and to a thickness of 4.7μm on the substrate d2. Pre-baking, ultraviolet ray exposure using a predetermined mask, development, and post-baking are performed to form the protrusion 52.

The thickness of the register material is determined by being measured by a stylus type step system like in the first embodiment.

Like the first embodiment, after panel assembling, as shown in FIG. 2, the protrusion 52 is arranged at a density of 1 per 4 dots and is uniformly distributed over color layers 3R, 3G, and 3B of red, green, and blue.

A result of measuring the height of the protrusion 52 in each color layer after formation of the protrusion 52 is shown in Table 3.

[Table 3]

Panel in which a protrusion is formed on an opposite substrate

Color filter	Color layer	After	After	Before and

substrate No. (Opposite substrate No.)	corresponding to position in which protrusion is formed	formation of protrusion, Protrusion height; Color layer thickness + Protrusion height (μm)	disassembling, Color layer thickness; Protrusion thickness(μm)	after assembling, Deformation in the height of protrusion height (μm)
C2 (a2)	Red	3.62 5.12	3.45 4.95	0.17
	Green	3.60 5.25	3.41 6.06	0.19
	Blue	3.61 5.41	3.34 5.14	0.27
d2 (b2)	Red	4.58 6.08	4.36 5.86	0.22
	Green	4.63 6.28	4.39 6.04	0.24
	Blue	4.61 6.41	4.28 6.08	0.33

Next, predetermined cleaning, alignment printing, and alignment layer hardening, and then rubbing in a predetermined direction and cleaning are performed on the two color filter substrates c2 and d2 and two opposite substrates a2 and b2 among the four opposite substrates 12.

At this time, an alignment layer 7 uses a polyimide-group material and its thickness is 50 – 80nm.

Next, seal printing is performed on the color filter substrates 11 and conductive paint coating is performed on the opposite substrates 12. At this time, a glass fiber having a length of 5.2μm is contained in the seal material.

After the opposite substrates 12 is bonded to the two color filter substrates 11, seal hardening, glass division cutting, vacuum injection of a liquid crystal 8, and a predetermined process for inlet sealing are performed, thereby making two liquid crystal panels. The color filter substrates 11 and the opposite substrates 12 are bonded such that the color filter substrates a2 and b2 are bonded to the opposite substrates c2 and d2, respectively.

The two liquid crystal panels are disassembled and the height of the protrusion 52 on the color filter substrates 11 is measured in each color layer. A result of disassembling the two liquid crystal panels is shown in Table 3 with a result after formation of the protrusion 52.

The effect of leveling of steps of color filter layers due to the protrusion 52 is not more efficient than the result of Table 3 in any of a protrusion forming process and a panel assembling process. As shown in FIG. 4, a sum of the thickness of each of the color layers 3R, 3G, and 3B and the height of the protrusion 52 is not uniform.

A sum of the thickness of each color layer and the height of a protrusion is the largest in a color layer having the largest thickness (the color layer 3B in this embodiment).

FIG. 6 is a schematic view when the leveling effect is sufficiently obtained.

From the above result, a protrusion formed in a color layer having the largest thickness supports a cell gap of a liquid crystal panel and it is efficient to control deformation in the height of a protrusion formed on a color layer having the largest thickness for stability of a cell gap.

Since the height and deformation in the height of protrusions are controlled based on the height and deformation in the height of a protrusion that overlaps a color filter layer having the largest thickness among color filter layers that overlap the protrusion, even when the protrusions are formed on a color filter substrate or a substrate opposite to the color filter substrate, the present invention can be applied to designing of a cell gap. In other words, it is necessary to design a proper height of a protrusion to obtain a desired cell gap, but it is important to know the height and deformation in the height of the protrusion after assembling to obtain a proper height of the protrusion and the proper height can be obtained by applying the present invention.

[Effects of the Invention]

By using the method for manufacturing a liquid crystal panel according to the present invention, it is possible to stably manufacture a liquid crystal panel having a stable cell gap and uniform display.

[Explanation on Drawings]

FIG. 1 is a schematic diagram of a liquid crystal manufactured using a method for manufacturing a liquid crystal panel according to a first embodiment of the present invention.

FIG. 2 is a schematic diagram illustrating a color filter substrate and arrangement of a corresponding protrusion according to an embodiment of the present invention.

FIG. 3 is a schematic diagram of a color filter substrate after disassembling of the liquid crystal panel according to the first embodiment of the present invention.

FIG. 4 is a schematic diagram of an opposite substrate after disassembling of a liquid crystal panel according to a second embodiment of the present invention.

FIG. 5 is a schematic diagram of a color filter substrate when a leveling effect is sufficient in a protrusion forming process or a panel assembling process.

FIG. 6 is a schematic diagram of an opposite substrate when a leveling effect is sufficient in a panel assembling process.

FIG. 7 is a schematic diagram of a liquid crystal panel that supports a cell gap using beads distributed by a conventional bead distribution method.

FIG. 8 is a schematic diagram of a liquid crystal panel manufactured by the method for manufacturing a liquid crystal panel according to the second embodiment of the present invention.

[Explanation of Numerals]

2: Black matrices

3: Color filter layer

3R: Color filter layer (Red)

3G: Color filter layer (Green)

3B: Color filter layer (Blue)

4: Transparent electrode

6: Array wiring

7: Alignment layer

8: Liquid crystal layer

11: Color filter substrate

12: Opposite substrate

51: Bead

52: Protrusion